The paradox of using residual feed intake or conversion ratios to study feed efficiency in dairy ewe

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Feed efficiency in dairy ruminants is a complex trait that has traditionally been estimated through feed conversion ratios (e.g. the ratio between the amount of feed consumed and the energy corrected milk production – FCR). More recently, the residual feed intake (RFI) is being increasingly used. This index is calculated as the difference between actual feed intake and predicted feed requirements for maintenance and milk production: the lower the RFI, the higher the feed efficiency. Both metrics, FCR and RFI, have been widely used in feed efficiency investigations. However, they probably reflect different mechanisms, which might lead to confusion or apparent contradictions. Therefore, this preliminary work was conducted to compare both indexes in a study carried out with 40 Assaf ewes with the aim of selecting the 20% most efficient and inefficient animals to investigate then the mechanisms underlying the animal-to-animal response. Data of daily intake, milk production, milk fat, protein and lactose, and live weight were collected individually to calculate RFI and FCR. Values of RFI ranged from -0.80 to 0.71 (on average, -0.02±0.063) and those of FCR from 0.61 to 1.52 (on average, 0.93±0.031). Unexpectedly, only 4 out of the 8 ewes classified as the most inefficient according to RFI were also within the 20% most inefficient animals when estimated with FCR. This behaviour was even worse when analysing the most efficient sheep: only 1 out of the 8 animals selected with RFI were confirmed with FCR. In addition, another 2 from the most efficient group according to RFI belonged to the most inefficient when classified by FCR. Only a poor, although significant, linear relationship (R^2=0.355; P<0.01) was found between both indices. The FCR is nowadays under question due to its correlation with animal size and performance, but still in use. However, many scientists, particularly geneticists, recommend RFI. The poor correlation between them would draw attention to and caution about paradoxical results when either RFI or FCR are utilised to estimate feed efficiency. Acknowledgements: Project CSI276P18, JCyL, FEDER and ESF, UE.

Ruminal biohydrogenation of dietary lipids in dairy sheep that differ in feed efficiency

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It is widely accepted that improving ruminant production requires an enhancement of feed efficiency (FE). However, mechanisms underlying this trait and explaining its large individual variation are still unknown. Some studies have examined the potential link between FE and ruminal microbiota, with certain bacterial populations being more or less abundant in more or less efficient animals. In addition, some of these bacteria might play a role in the biohydrogenation (BH) of dietary lipids and produce bioactive intermediates, which could perhaps be related to FE. To examine this potential relationship, the FE was estimated in 40 lactating Assaf ewes through the residual feed intake to identify the most (n=8) and least (n=8) efficient animals. Rumen samples were collected with a stomach tube and analysed for fatty acid (FA) composition by gas chromatography. An ANOVA was performed to compare the response in both groups of sheep. Results showed a greater proportion of unsaturated fatty acids (UFA) of dietary origin and of several BH intermediates (e.g. cis-9 cis-12 18:2, trans-9 cis-12 18:2, cis-9 18:1; P<0.10) in the rumen of less efficient animals. In contrast, an increase of stearic acid (18:0; P<0.05) was observed in more efficient sheep, supporting a larger extent of the BH process. Variations in certain odd-chain FA were also found: the content of 17:0 was higher in the most efficient ewes, while that of 13:0 was higher in the least efficient (P<0.10). Although these FA are synthesised de novo by ruminal bacteria, available information is too scarce to use them as indicators of changes in specific biohydrogenating groups. In summary, our results show differences in the ruminal BH pattern in dairy ewes that differ in FE, with lower UFA, and greater 17:0 and 18:0 concentrations in the most efficient animals. Further research is needed to understand the role of the rumen microbiota, particularly that involved in BH, and its potential link with feed efficiency [Acknowledgements: Project CSI276P18, JCyL, FEDER and ESF, UE].

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INTRODUCTION

- A sustainable increase in livestock production would require selection for improved feed efficiency, but mechanisms underlying this trait and explaining its large individual variation in dairy ruminants are still unknown.

  Some studies have examined the potential link between feed efficiency and ruminal microbiota, with certain bacterial populations being more or less abundant in more or less efficient animals.

  Our hypothesis: differences in rumen microbiota might affect the biohydrogenation (BH) of dietary lipids, with accumulation of bioactive intermediates that could be related to feed efficiency.

MATERIAL AND METHODS

H-FE; n=8

L-FE; n=8

Experimental conditions: (3 weeks)
- TMR (50:50 F:C)
- Ewes allocated in individual tie stalls
- 2 milkings/day

1) Data of daily DM intake and milk yield were collected individually to estimate **feed efficiency** as: actual DM intake – predicted DM intake (estimated based on AFRC requirements)

2) Ewes showing divergent feed efficiency phenotypes were selected: high-feed efficiency (**H-FE**) and low-feed efficiency (**L-FE**)

Ruminal **fatty acid (FA) profile** by GC

Fermentation parametres
(pH and ammonia and volatile FA -VFA- concentrations)

RESULTS

Feed intake was similar in **H-FE** and **L-FE** ewes.

Ruminal FA composition

FA, g/100 g total FA	L-FE	H-FE	*P*-value
cis-9 18:1	6.437	5.262	0.07
cis-11 18:1	0.513	0.502	0.72
cis-12 18:1	0.647	0.472	0.09
∑ *cis* 18:1	8.021	6.659	0.04
trans-6+7+8 18:1	0.579	0.48	0.09
trans-9 18:1	0.356	0.294	0.1
trans-10 18:1	0.835	0.616	0.16
trans-11 18:1	5.728	4.854	0.15
trans-12 18:1	0.901	0.752	0.12
∑ *trans* 18:1	11.953	10.234	0.07
cis-9 *cis*-12 18:2	8.016	6.355	0.02
trans-9 *cis*-12 18:2	0.04	0.027	0.04

the concentration of 18:2 n-6 and of some of its BH intermediates, such as *trans*-9 *cis*-12 18:2 and *cis*-9 18:1, were greater in **L-FE**

In contrast, an increase in stearic acid, which represents the final product of BH, was observed in **H-FE**

Higher extension of BH in more efficient ewes (H–FE)

No variations in BH metabolites
suggesting differences in specific pathways or steps between **H-FE** and **L-FE**

No differences in VFA concentration and molar proportions.
However, ammonia concentration was significantly greater, and the acetate:propionate ratio tended to be slightly greater in the **L-FE** ewes.

CONCLUSIONS

Under the conditions of our study, results support a relationship between FE and the apparent **extension of biohydrogenation**, a process that would be **more complete in more efficient ewes**

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